THE AMERICAN POTASH INDUSTRY

CATHERINE D. BOYD

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CONTENTS

I Introduction

Developing from a product of narrow industrial utility, potash is definitely established today as a commodity of national importance and international prominence, both in agriculture and in industry. In Germany the potash industry, one of its largest and strongest, is a barometer of business. The lack of potash as a natural resource in other countries and its corresponding importance to agricultural livelihood have stimulated an active, world-wide search for possible domestic sources. The United States is particularly interested in the development of an American Potash Industry which will supplant the present German importations, and since the War has intensified its investigations for the sole reason of avoiding the repetition of a potash embargo such as was imposed during the 1914-1918 debacle.

It is difficult to say just when potash came into use. Its versatility was known long before the momentous German discoveries at Stassfurt established it as an economic necessity. The earliest known sources of potassium were natural and decayed animal and vegetable matter, including wood ashes, animal refuse, bones, and fish. In early times, potash was confined primarily to industrial processes, although the ancient farmer

knew of its excellence as a soil fertilizer. Romans in the period before Christ also discovered the intrinsic cleaning properties of potassium carbonate reduced from wood ashes.[1] At a later period, on the American continent, the Indians learned that applications of dried fish enriched the soil and improved the quality of the crop - a custom that was readily adopted by many early American settlers.[2] Gradually, by the middle of the nineteenth century, the use of potash had expanded into the manufacture of various products, such as, soap, glass, medicines, agricultural fertilizer, and for numerous chemical purposes. It was not until 1850, however, that German chemists discovered enormous potash deposits in the salt mines at Stassfurt, Germany, an event which completely revolutionized the industry and placed potash on the map, literally over night. Subsequent discoveries in several other regions in Germany revealed a prolific supply estimated to be sufficient to satisfy world requirements for two thousand years to come.[3]

At that time, the best prospect for immediate absorption of potash in large quantities was the agricultural industry. Straightway, German interests, aware of the monopolistic nature of the newly discovered deposits, advanced an intensive program of propaganda to enlighten the agricultural world and educate the farmer to the

1. Stocking, G. W., "The Potash Industry", p. 43
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necessity of potash as an essential ingredient of farm fertilizer. The United States was particularly responsive to the German sales campaign and eventually became a large importer of German potash. Sales gained considerable momentum in the last half of the nineteenth century and by 1913, imports reached a total of 255,100 tons. By this time, the American farmer had become so wholly dependent upon the German product that a complete cancellation of supplies during the war left him with a serious shortage in plant foods. Then it was that the necessity of developing a domestic source of supply was emphasized with all the force of a national calamity. The subsequent period between 1914 and 1918 marked an amazing rise and fall of the American Potash Industry. Immediately after the War, high production costs and a return to cheap German potash defeated the initial efforts of this gallant little industry which had managed to fulfill one-fifth of domestic requirements up to 1918. Under pressure of powerful German competition, only two of the two hundred and eighty-eight war-time plants survived the post-war deflation. Beneath the stimulus of a bitter experience, however, the American Government intensified the search for domestic potash which could be developed at low-cost and offered to American consumers at prices as low as the German product.

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It is an interest in the possibilities of these findings which has prompted the present undertaking. Even though evidence is still inconclusive as to the possible dominance of an American industry in its own home market, yet there have been some very encouraging discoveries made within the last two years which point with favor to a profitable domestic industry almost within grasp. Because of the peculiar characteristics inevitably associated with potash production, and because the German industry still dominates the world, it seems a logical procedure to discuss the older industry first so that the potentialities of a new American industry may be accurately appraised.

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II. Uses

Statistics have shown that over ninety per cent of the production of potash is used in the production of fertilizer.[1] To give the best results plant life requires sufficient amounts of the three fundamental elements of fertilizer, namely, nitrogen, phosphoric acid, and potash. These elements when applied to the soil supply plant life with a weapon against disease and plant decay, prevent discoloration of leaves, produce a better flavor in fruits and wine, and improve the aroma and burning quality of tobacco. According to J. W. Turrentine, the functions of potash used in fertilizer material are two - first as a "conservation measure"[2] and second, as a "labor-saving device."[2] Mr. Turrentine, who has been for many years in charge of the potash investigations of the United States Bureau of Soils, emphasizes the fact that potash is indispensable in restoring to the soil the necessary chemical elements removed when crops are harvested. Likewise, it insures greater yield per acre, thereby, decreasing the unit cost of labor. A poor crop requires practically the same amount of labor and cultivation as a good crop, for the application of potash takes care of soil deficiency and automatically increases the yield. In addition to scientific tests conducted by agricul-

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tural stations the world over, no better evidence can be offered to substantiate these contentions than the response of farmers, who, in normal times, have continued to buy potash in increasing amounts.

In this country, potash is particularly essential in the cultivation of the light sandy soils of the South where the bulk of cotton, tobacco, and citrous fruits is grown. The need for potash, especially in this region, was emphasized during the War when imported supplies were cut off and American farmers had to rely on the extremely limited and expensive supply derived from an emergency production at home. The extent to which crops were affected is revealed in a report to the Economic Conference at Geneva in 1927 which presented a statement given in an official publication of the American Department of Commerce to the effect that "owing to the lack of potash in the years 1917 and 1918 enormous amounts of vegetables reached the market in a rotten condition so that farmers experienced a serious loss, and detriment was caused to the nourishment of the people as a whole." On the same subject Mr. Frederick W. Brown, writing from the Department of Agriculture, has observed that "throughout the cotton states, the tobacco-growing regions, the trucking sections of the

Atlantic States, and in citrus-fruit and potato-growing regions, the heavy application of commercial fertilizers, including potash, is now a recognized agricultural practice."[1]

Although the uses of potash today are primarily agricultural, its value in innumerable other industries has already been scientifically established. Despite the fact that a relatively small percentage of the entire production enters industrial and chemical processes, its use along these lines is distributed over a wide and varied field. Potash constitutes an essential element in the manufacture of explosives, including shrapnel powder, hand grenades, primers, fuses, and pyrotechnic devices.[2] It also enters the match industry as the best oxidizing agent obtainable. Soaps, liquid and solid, depend upon the caustic properties of potash for saponification. In addition, it is used in the manufacture of high quality glass intended for special purposes, such as, lenses for optical instruments, cut glass, and electric-light bulbs.

Its importance in the chemical industry cannot be overlooked, for the constituent of potassium appears in many pharmaceutical and medical preparations. Germany was the first to make a business of refining crude salts, and as a result the small bulk of concentrated salts used

1. Brown, F. K., "Importance of Developing Our Natural Resources of Potash", Agricultural Yearbook, 1916.
2. Devices used in the making of fireworks for public celebrations.

in the chemical industry could be easily obtained. In the year 1922, seventy-six out of eighty chemical plants in Germany were engaged in refining potash and preparing the different products obtained for specific uses in many lines of trade; such as, photography, painting, aniline dyeing, cleaning, bleaching, weaving, as well as the manufacture of paper and electrical apparatus.[1]

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III. Chemical Composition

Very often the terms "potash", "potash salts", "potassium", or "actual potash" are used indiscriminately by the layman, but to the chemist or the fertilizer manufacturer these terms convey a very definite meaning. By "potash" is meant potassium oxide or K_2O which has been arbitrarily adopted as a standard of measurement in making comparisons.[1] All potash salts or compounds of potash contain the element of potassium represented by the symbol K. The form K_2O or potassium oxide is used only as a yard stick in reducing the potash content of all salts or compounds to a common basis. It is merely a hypothetical term, is never found as such, and is never marketed as such. Potash reaches the market only in the form of chlorides or sulphates, although prices are determined on the basis of the K_2O content. In the potash trade, however, the term "potash" has substituted largely for the term potassium oxide--the specific term "actual potash", merely emphasizing the actual amounts of K_2O present in the product. "Potash salts", on the other hand, are merely salts found as mineral deposits in their crude state, containing elements of potassium mixed with other mineral compounds. J. W. Turrentine clarifies the meaning in his statement that "every potash salt, even though it

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be ~~one~~ hundred per cent pure, must be recalculated to its equivalent of the hypothetical oxide, K_2O.[1]

The following table, taken from the United States Geological Survey Bulletin 530-B, gives the percentage of potassium and the combination known as potash present in the various potassium compounds and minerals:

POTASSIUM AND "POTASH" IN POTASSIUM COMPOUNDS

Name	Symbol	% of potassium (K)	Chem. equivalent in terms of "potash" (K_2O)
Element			
Potassium ----------------	K ------	100	--------
Potassium salts or "potash salts"			
Potassium chloride (mineral sylvite)	KCl	52	63
" muriate (same as chloride)			
Potassium sulphate ----------	K_2SO_4	45	54
Potassium nitrate (saltpeter)	KNO_3	39	47
Potassium carbonate----------	K_2CO_3	57	68
" hydrate or caustic potash	KOH	70	84
Potassium cyanide------------	KCN	60	72
Stassfurt minerals			
Carnallite ------------------	$KMgCl_3.6H_2O$	14	17
Kainite ---------------------	$MgSO_4.KCl.3H_2O$	16	19
Sylvite (potassium chloride)--	KCl	52	63

Potash deposits occur in varying mixtures and varying concentrations, according to their geological character. Usually the deposits are of chloride or of sulphate origin mixed with sodium or magnesium salts.

1. Turrentine, J. W., "Potash", p. 3

If the potash content is high they may be used directly as a fertilizer without being subjected to a refining process. If, on the other hand, the potash content is low, refining is necessary in order to rid the product of unnecessary impurities and elements. Of late years, there has been a growing demand for the refined product because of a desire to eliminate the unnecessary expenditure of freight on irrelevant material. Although many salts occur in the various areas of production, there are certain broad classifications made according to geographical distribution. German deposits occur chiefly as carnallite, hartsalz, or sylvite;[1] the French deposits,largely as sylvite;[2] and the American deposits in Texas and New Mexico,as polyhalite and sylvite.[2]

Besides the common chloride salts found in Germany and Alsace, namely, carnallite, kainite, and sylvite, and the rarer sulphate salt, polyhalite, there are certain mixtures of potash-bearing minerals and non-potash-bearing minerals which have been classified according to trade names as follows:[3]

Sylvinite:"A mixture of rock salt or sodium chloride and sylvite or potassium chloride with a little kainite."

Hartsalz: "A mixture of sylvite or potassium chloride,

1. Stocking, G. W., p 222
2 Wroth, J. S., "Commercial Possibilities of the Texas-New Mexico Deposits", Bureau of Mines, Bull. 316, p. 16, 1930
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Manure salts: "Consists chiefly of sodium chloride and potassium chloride with variable but small amounts of other salts."

Double manure salts: "Consists essentially of the double sulphate of potassium and magnesium."

IV. The German Potash Industry

It was chance that had made known the potash deposits in Germany. Since the thirteenth century the valuable Stassfurt mines had been worked near the surface for salt only.[1] As the demand for salt grew the surface supply became inadequate; government engineers bored deeper for further sources and accidently unearthed an uncommon, bitter salt, called at the time "abraumsalze" and pronounced worthless by the discoverers. Later investigations of the same "abraumsalze" by Doctor Justus von Liebig revealed that the mineral contained valuable quantities of potassium, a potentially important element of farm fertilizer. Herein lay the force which was to set in motion a tremendously important industry. The Prussian Government was the first to exploit and operate the mines in 1857 and continued to maintain a dominating influence even though private companies also entered the field in strenuous competition.

In 1861 a new area was opened up by the Duchy of Anhalt near Leopoldskall; production of the deposits were started on a commercial basis in 1862. From 1862 to 1875 the exclusive production of potash was carried on in these two states, Prussia and Anhalt, although the refining, processing, and ultimate marketing were

1. Hoar, H. M., "Potash: Significance of Foreign Control and Economic Need of Domestic Development", Bureau of Foreign & Domestic Commerce, 1926, Trade Promotion Series No. 33, p. 4

entrusted to private hands. Participation of the state in the mining operations of the industry was merely another manifestation of the old German theory of "royal prerogative" which allowed the government, and only the government, to operate mines. This theory solidified during the growth of mercantilism, which emphasized "the guidance of industry toward state ends"[1] as opposed to the theory of individualistic enterprise ushered in by the Industrial Revolution.

Finally, in 1865, the traditional mercantilistic theory, which so rigidly controlled industry and business in Germany for centuries, gradually disintegrated. Prussia was the first to open its mines to the general public; thereupon, other states followed, extending to individual enterprise a natural right which for so long belonged exclusively to the state. Under the impetus of the new industrial regime, the potash industry flourished and grew. The first private potash mine opened for business in 1875 and two years later Stassfurt began operations as a private concern. Production figures of crude potash jumped to 770,273 metric tons representing 63,392 tons of K_2O, 3424 tons directed to agriculture, 30,771 tons to the chemical industry, and

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the rest, finding its way to foreign ports.[1]

The remedy, however, seemed to create a new obstacle which threatened to become a chronic problem. The whole situation revolved around the superabundance of deposits and the ease with which additional producers could enter the industry under the new force of competition which was destroying rather than controlling its equilibrium. These conditions were due primarily to the fact that only a rough estimate could be made of the underlying strata - a factor which flooded the industry with an overwhelming number of optimistic prospectors. It was inevitable that a constantly increasing production of potash salts caused an expansion of capacity far exceeding current demands. In the potash industry, capacity did not respond to the ordinary force of supply and demand but increased all out of proportion to the demand. The irregularity may be further traced to the inelasticity of the demand for potash, motivated not by price but by the effectiveness of sales propoganda and the general prosperity of the farmer. Hence, it is evident that early in its history the question of capacity control in the German Potash Industry had already become a baffling problem. Professor Stocking summed up the nature of the demand for potash in a single generalization to the effect that

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"propaganda, coupled with general conditions of agricultural prosperity, and not price, would seem to be the prime determinant regulating the amount of potash which finds its way to the soil.[1]

Overcapacity had its inception when the private works began to operate. By 1877, it was commonly stated that anyone of the four mines producing were individually capable of satisfying the entire market demands for potash.[2] That the situation was acute was shown by the action of the Prussian fiscus in trying to create some sort of agreement among the producers as to the regulation of prices and allocation of output. At first the effort proved futile because smaller works refused to accept a comparatively smaller quota. Later, however, in 1879, upon a considerable decline in the price of potassium chloride, private works accepted the terms and became parties to an agreement limiting the production of potash, allocating the market, and raising the price of carnallite twenty-five per cent.

The carnallite agreement of 1879 proved to be the precursor of the German Potash Syndicate which was formed ten years later. During this intervening ten-year period the industry prospered, although agreements were of increasingly shorter duration and were

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In spite of these occasional ripples in the business progress of the industry, the years 1883-1887 had an extremely satisfactory outlook. A central sales office idea had been introduced into the muriate fac-

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There is no doubt that the cartel resulted in a period of prosperity in the industry for the next ten years. That prosperity can be explained almost wholly by the increase in the demand for potash in the late nineties in spite of a simultaneous increase in capacity which cut down the quotas of the individual mines. Until 1882, the demand had been steadily forging ahead of the growth of new mining companies, with the result

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that the quota allotment assigned to each company actually increased. Hence, productive output was stabilized prior to 1900, as shown by the fact that "the average production per company was about the same in 1900 as it had been in 1883."[1] The slack had been taken up opportunely by the new industrialization of Germany and a vigorous propaganda campaign inaugurated by the Syndicate.

In spite of apparent healthy conditions in the industry in the last few years of the century, increasing demand, increasing prices, and declining costs were attracting a disconcerting number of new producers into the fold. The protective influence of the Syndicate in maintaining a high price schedule for potash served as a primary stimulus. A steady rise in demand enlarged the prospects. Finally, a decrease in production costs as a result of the technological advance in machinery proved to be even more alluring. Mechanical power had superseded the crude pick-and-shovel method of sinking shafts. Excavations were simplified by a new percussion tool, which, through a churning process, cut into the prospective area with speed and thoroughness. Likewise, the recovery process was improved by the introduction of a new diamond-core drill, a device that yielded circular cross sections of

Stocking, G. W., "The Potash Industry", p. 77

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the underlying rock formations, thereby, making possible an accurate analysis of deposits as to extent, character, and location. Such developments, encouraging as they might be to any ordinary industry, gave promise of becoming disastrous to the potash industry. Unrestrained competition was gaining new impetus; The significance of this competition showed in the fact that the number of concerns had grown twice over between 1889 and 1900; in two years this number increased fifty per cent and in five years, approximately two hundred and thirty-five per cent.[1]

The years 1900-1910 were troublesome years for the German potash industry. The cartel of 1888 had been renewed for a three-year period in 1898, establishing a central sales bureau through which prices and quotas were regulated. Upon its expiration in 1901 the agreement was renewed for a second time. The brief duration of agreements plus the difficulty in renewing them indicated a fundamental weakness within the industry. As new concerns appeared quotas contracted and friction resulted. Trouble was brewing at the appearance of many new concerns and the consequential contraction of quotas. The younger mines demanded higher quotas on the basis of relatively high production capacity; the older mines expressed bitter resent-

1. Stocking, G. W., p. 90.

ment against these demands and insisted upon maintaining their original quotas. Meanwhile, in 1904 the 1901 agreement was presented for renewal. Assent to the stipulations of the new agreement was unanimous with the exception of the Hedwigsburg mine, but this dissenting action on the part of one mine was sufficient to nullify the agreement. With the clamps of Syndicate control released, the Hohenfels mine seized the opportunity to free-lance and made five-year contracts with American buyers at prices below the Syndicate quotations. Concerted action on the part of the various producers in the Syndicate and concessions made with Hedwigsburg finally resulted in an agreement in the summer. In the same year, the Syndicate underwent reorganization. A most important change was made in the new legal aspect which it adopted. Hereafter, "its members could be legally constrained to turn over the entire output of potash salts to the central sales office."[1]

Nevertheless, lack of sufficient control threatened the industry. Producers continued to multiply and the Prussian State grew alarmed. In 1905, Prussian intervention finally led to the "Gamp Law" which abandoned the "Berghanfreiheit"[2] of 1865, giving private citizens the right to prospect for minerals with com-

1. Stocking, G. W.,
2. Freedom of mining. According to this theory the public was at liberty to prospect anywhere in the State without restriction. Upon discovery of a mineral the prospector was granted a lease after which the mine could be developed.

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plete freedom. The law, contrary to expectations, had the undesired effect of driving more producers into the field before its actual passage was completed. Its general effect was to shift the area of potash development to the districts of Thuringia, Alsace, and Hannover, all non-Prussian territories where frenzied speculation and exploitation became the order of the day. In addition to these difficulties the Syndicate was besieged with new, unsolvable problems. Parent companies were undergoing gradual disintegration in order that an adequate number of subsidiaries might be established to expand quota allotments. The younger concerns were becoming successful in dictating Syndicate policies. An enactment of two-shaft ordinances fostered a community of interests between otherwise competing concerns, for sharing shafts effectively covered the law. Finally, the evils of over-production and overcapacity were beginning to seep in. "In this connection," says H. M. Hoar, in writing from the United States Department of Commerce, "during the period 1900-1908 the average output per syndicate mine had, owing to decrease in quotas, dwindled to 41-45% in quantity and 47.8% in value."

In 1904, the Syndicate had forced in line several independents, but the measures adopted did not prevent

members from surreptitiously making contracts abroad. This situation became apparent in 1905 when the Sollstedt mine, controlled by the Schmidtmann family, made independent contracts with American buyers at prices considerably lower than those fixed by the Syndicate. The latter had previously refused to depress general potash prices and concede a larger quota allotment to Sollstedt. In retaliation, the Syndicate again lowered prices as a means of compelling Sollstedt to join the organization; it also offered an inducement of an 11-13% discount to the two largest American purchasers, the American Agricultural Chemical Company and the Virginia-Carolina Chemical Company, as well as, a 5-7% discount to smaller purchasers who would patronize the Syndicate exclusively. All manner of trade devices, however, proved futile. Sixty-five American companies, former customers of the Syndicate, turned to the Schmidtmann mine for future deliveries, to begin in 1910 upon the expiration of their former contracts. During 1907, the threat of imperial action was successful in forcing Schmidtmann to accept the Syndicate terms, but further discrimination against American buyers was responsible for a second withdrawal on the part of Sollstedt.

In 1909, the usual renewal of Syndicate agreements

was blocked by dissension among the independent mines and a mutual attack upon the Syndicate by the four largest mines.[1] The following year came the inevitable climax - direct governmental action in the form of a Potash Law, whereby the German Imperial Gevernment reassumed its traditional role as regulator of the industry. At the basis of this legislation, first and last, were the American low-priced contracts. The importance of the American market in supporting an industry which must remunerate even the high-cost producer is reflected in Professor Stocking's statement that "although foreign markets formed only 46.6 per cent of the total market in 1900, in doppelzentners[2] they represented 61.8 per cent in value." He further adds that "of the foreign market, America was easily the most important, overshadowing all others combined, and comprising in 1910 more than one-fourth of the entire market for potash, domestic and foreign."[3] It is clear, then, that the hold of the Syndicate on the American market had been jeopardized by the invasion of independent producers offering lower prices.

With one sweeping gesture, the imperial government invalidated the American contracts, reestablished Syndicate prices at higher levels, and interpreted the Potash Law of 1910 in such a way as to penalize the

1. Sollstedt, Aschersleben, Einigskeit, and Westergeln.
2. One-tenth of a metric ton or 220 lbs.
3. Stocking, G. W., p. 113

American buyer rather than the German producer. Both domestic and foreign sales were apportioned equally; individual mines making contracts over and above their quota were fined accordingly. Contracts made in excess of the fixed allotment could be fulfilled only upon a raising of the price one hundred per cent higher than quota prices. As effected by fines imposed on excess imports, the price of muriate of potash rose from $20.40 to $40.50 per ton, five dollars more than the Syndicate price.[1] Naturally, the American purchaser protested against such discrimination, and even demanded governmental action, but after failure to obtain any definite response, submitted in utter helplessness to the dictatorship of the German monopoly.

The struggle for normal industrial existence, however, was by no means over for the German potash industry. Where one evil had been uprooted another appeared in its place, this time in the form of an unprecedented growth of new enterprises and an expansion of productive capacity five times the quantity needed for consumption. Provisions of the Potash Law of 1910, allowing transfer of quotas and ownership of stock led to two distinct developments within the industry - concentration of production and an intensification of the race for new shafts upon which large quotas could be based. New

1. Wroth, J. S., "Commercial Possibilities of the Texas-New Mexico Potash Deposits", Dept. of Commerce Bulletin, No. 316, p. 134

shafts were purchased or constructed with this one end in view, and then having accomplished their purpose, were permanently abandoned. The following data illustrates the extent to which this development took place:[1]

YEAR	NO. OF MINES PRODUCING	NO. OF MINES UNDER CONSTRUCTION	NO. OF MINES WITH COMPLETE BORINGS
1911--	-----69	79	50
1912--	-----97	113	
1913--	----127	132	

On the other hand, the consolidation movement was one of the few advantageous developments of the Potash Law. In the process of transferring quotas and purchasing controlling interest in various subsidiaries, there emerged several strongly centralized companies which were able to concentrate production upon the most efficient mines. In addition, because of the monopolistic nature of the industry, artificially high prices could be maintained and a foreign price differential sustained, which was responsible for the reaping of profits in spite of internal maladies. Sales of pure potash, in 1913, amounted to 1,110, 369 metric tons, valued at $45,696,000.[2]

Whatever progress the German potash industry had been making under imperial control was suddenly interrupted by the World War. Sales to foreign markets rep-

1. Hoar, H. M., p. 18
2. Hoar, H. M., p. 23

resenting 46% of the total market immediately declined. Domestic prices were relatively low, allowing only small profits to the producer. At the same time, the price of fuel and wages rose to abnormal levels. A shortage of labor, supplies, and limited transportation facilities also resulted. Finally in 1915, an embargo placed on the export of potash completely crippled the industry in Germany. Likewise, gross tonnage received at American ports showed a steep decline:

Imports of German Potash to the United States[1]

YEAR	TONS OF PURE POTASH
1910-1913(average)	269,656
1914	207,089
1915	48,867
1916	8,000

By the drastic terms of the Armistice, Germany was forced to cede to France its Alsatian deposits, "the youngest, the richest, and the most potentially valuable of its potash mines."[2] These had been discovered in 1904 near Wittelsheim where the territory was being drilled for coal and oil. Shortly afterward exploitation of the deposits was begun by fourteen mining companies, ten of which were controlled by the three largest German groups, and the remaining four, by a Franco-Alsatian private group known as the Syndicate

1. Hoar, H. M., p. 23
2. Stocking, G. W., p. 148

Sainte Therese. After the War, the French Government acquired control of the German mines, operating them under the title of Les Mines Domaniales de Potasse d'Alsace, although the Sainte Therese group continued under private ownership and control. The only attempt to coordinate both groups was through a common sales agency established to handle sales both at home and abroad and to disseminate propaganda for their mutual interests. At present, these are the only two mines producing potash in France.

Comparatively speaking, the Alsatian deposits had decided economic advantages over the remaining German deposits at this time. It is true, the latter were more extensive, but were scattered over an area of 24,000 square miles from the vicinity of the Harz Mountains in the east to the Hanoverian lowlands and Thuringia in the west. Their total productive capacity amounted to approximately two billion tons of potash in terms of K_2O. The Alsatian deposits, on the other hand, were grouped together in an area of seventy square miles, with a total capacity of 200-300 million tons of pure potassium oxide. The French deposits were more regular, occurring in two layers at a depth of about 2,000 feet, while the German deposits were distributed over a large area, some occurring near the

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In the post-war period, Germany's position as a potash producer was considerably altered. Previously, at every step of industrial development, it was impregnable because of the natural world monopoly. In spite of promiscuous waste of deposits, inefficiency of shafts, and bitter internal strife, the industry flourished, notwithstanding treaty concessions. Its supplies at the close of the War were still inexhaustible, greatly exceeding the output in any other part of the world. Due to the excellence of the French deposits, however, their concentration in a small area, and their low treatment costs, French prices had the advantage. Consequently, the German industry demanded prompt reorganization. The war interrupted early attempts on the part of the newer groups, particularly Wintershall, to reorganize. It was not until 1919 that a new German Potash Law accomplished complete reorganization of the industry, henceforth placing it under the direct condevelopment which made it necessary for the strong companies to support the weak through the instrument of an artificial price. During the period from 1918 to 1920, German production declined well over one million tons. The maintenance of unutilized plants and the use of obsolescent machinery were other factors in retarding its progress.

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Under the new industrial socialization regime, the German potash industry rallied with remarkable speed. Production figures approached their pre-war level, despite the fact that French production had doubled. A general business depression had set back the industry in both countries in 1921, but a reaction in 1922 brought new prosperity that mitigated the

1. Report of the International Economic Conference at Geneva, 1927, p. 7

danger of French competition. The distressing economic situation in Germany in 1923 with currency deflation, industrial difficulties, and high-cost supplies aggravated another potash depression, causing a serious decline in domestic sales. Likewise, the French industry in 1924 was confronted with labor troubles which made the situation ripe for a Franco-German agreement. Consequently, in 1924, the two countries entered upon an agreement whereby prices were fixed, sales allocated, and markets divided. The first agreement was confined to the American market alone, where sales were to be divided in the ratio of 37.5% to France and 62.5% to Germany. A later agreement included the entire world market, Germany receiving 70% and France, 30%. In addition, the agreement was to run for a period of ten years, after which it could be renewed for three years and thereafter for five-year intervals. Strained diplomatic relations between the two countries did not affect in any way the smooth, satisfactory functioning of this international potash cartel. Government control of both industries and a mutual acknowledgment of trade benefits provided an effective check against unethical business practices or disagreements. The year 1925 was a danger of French competition. The distressing economic situation in Germany in 1923 with currency deflation, industrial difficulties, and high-cost supplies aggravated another potash depression, causing a serious decline in domestic sales. Likewise, the French industry in 1924 was confronted with labor troubles which made the situation ripe for a Franco-German agreement. Consequently, in 1924, the two countries entered upon an agreement whereby prices were fixed, sales allocated, and markets divided. The first agreement was confined to the American market alone, where sales were to be divided in the ratio of 37.5% to France and 62.5% to Germany. A later agreement included the entire world market, Germany receiving 70% and France, 30%. In addition, the agreement was to run for a period of ten years, after which it could be renewed for three years and thereafter for five-year intervals. Strained diplomatic relations between the two countries did not effect in any way the smooth, satisfactory functioning of this international potash cartel. Government control of both industries and a mutual acknowledgement of trade benefits provided an effective check against unethical business practices or disagreements. The year 1925 was a prosperous one for both industries - sales in Germany increasing 50% over 1924 and in France, 12%. American sales also expanded considerably. The German Potash Industry did more business in 1927 than in any year since the War. It was gradually consolidating into fewer and larger groups, so that by 1927, 80% of production quotas lay in the hands of three of the largest mines: Wintershall, Salzdetfurth, and Burbach. The following table shows the percentage grouping of quotas in 1927:[1]

NAME OF MINE	% OF TOTAL QUOTA ALLOTMENT
Wintershall	39.6
Salzdetfurth-Aschersleben	23.7
Burbach	17.3
Prussian Fisc	5.8
Kali-Chemie-Fredrichshall Neutassfurt	4.6
Anhalt-Fisc	3.5
Solvay	2.5
Hohenfels	2.2
Hallesche	.8
	100.0

When the sales of 1928 were beginning to show an even more encouraging increase, the German Pot-

1. Wroth, J. S., "Commercial Possibilities of the Texas-New Mexico Potash Deposits", Dept. of Commerce Bulletin, No. 316, p. 139

ash Industry felt the impact of the current world-wide depression. Sales which had reached the peak of 1,420,000 tons of pure potash in 1928 declined to 1,350,000 tons in 1930 and slumped to 970,000 tons in 1931.[1] Exports showed the greatest reduction, since the domestic consumption declined only 15%. The plight of the German farmers prompted a reduction in the price of potash which was granted by the German Cabinet on December 8, 1931, "enforcing a 10% price-cut on all syndicated or cartellized commodities."[2] The three largest concerns reduced their dividends as follows:

Wintershall----------------12%-8%

Salzdetfurth---------------15%-10%

Aschersleben---------------10%-7%

Although further reductions seem inevitable, the German Potash Industry still stands as one of the bulwarks of the German industrial regime. According to the observations of Professor Stocking it ranks "among the strongest in the entire German economic system."[3] Overwhelming economic hardships have served to strengthen its framework and discipline its organization. Up to 1930, its natural monopoly of world potash still remained intact, despite the French concessions in Alsace. Government control

1. Taken from "German Potash Industry Hit by the Depression", Chemicals, February 8, 1932.
2. The same
3. Stocking, G. W., "The Potash Industry", p. 296

has partly solved the problem of over-capacity, although that is the one dominating problem which overshadows its success. Today, the industry remains undaunted by new evidences of foreign competition.

Meanwhile, on the other side of the Atlantic, spectacular developments have taken place in a new American Potash Industry. Latest reports claim that the United States is ready to declare a "declaration of independence"[1] of the German monopoly. It is reasonable to suppose, however, that, if such an industry does materialize, the same difficulties which confronted the German industry will offer serious handicaps, unless they are solved in the light of German experience. Only by an orderly development, based on a thorough knowledge of German problems, can an American Potash Industry hope to succeed.

1. "Potash Independence", Business Week, Feb. 22, 1933.

V. The American Potash Industry

The history of American potash developments falls into three periods. The first period (1911-1914) was marked by an active governmental investigation for all possible domestic sources. During the second period (1914-1918) every source, previously disclosed, was developed in an attempt to counteract an acute shortage caused by the German embargo. The third period, after the War, was one of deflation and an inevitable return to German potash; but very recent discoveries in Texas and New Mexico make a new era in the American industry well within the realm of possibility.

Prior to 1914, almost all the potash consumed in the United States was imported from Germany. The average consumption for the years 1910-1914 amounted to 270,000 tons.[1] Shortly after the passage of the German Potash Law of 1910 and the consequent invalidation of American contracts, interest was aroused in the possibilities of domestic sources of supply. As a result, in 1911, the government inaugurated a program of surveys and investigations conducted by the United States Geological Survey and the Bureau of Soils for which an appropriation of $52,500 was

1. J. S. Worth, p. 10

VI The American Potash Industry

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1. J. S. North, p. 10

granted. To the Geological Survey was entrusted an investigation of the natural sources of supply, including the brines of salt lakes, rock formations, and natural salt beds. A list of its major activities is given in the United States Department of Commerce Bulletin, No. 316, as follows:[1]

1)"Studies of the natural brines in the salt lakes of California, Utah, Nebraska, Nevada, Texas, and other States, and of the saline deposits in "dry lake beds."

2)"A comprehensive investigation of the salt industry and of the potash content of bitterns from salt work residues."

3)"The drilling of salt deposits in Nevada and Texas, the results of which unfortunately were disappointing."

4)"Investigation of the alunite deposits of Utah and other States, with experiments on the recovery of potash from alunite."

5)"Investigation of the leucite rocks of Wyoming and of other basic igneous rocks in various localities."

6)"A study of the salt beds of western Texas and eastern New Mexico, where potash salts were discovered in a well drilled in 1912."

1. J. S. Wroth, p. 124

The same report[1] lists the activities of the Bureau of Soils as follows:

1)"A detailed study of the seaweeds and kelp of the Pacific coast, and of the recovery of potash from raw material of this type."

2)"The extraction of potash from silicate rocks, including feldspars, New Jersey greensands, and Georgia sericites."

3)"The recovery of potash from cement-plant flue dust, and from blast furnace flue dust."

4)"Tests with alunite, feldspars, and kelps as direct fertilizers."

Investigations disclosed that the sources of domestic potash could be classified into three major groups - natural deposits, trade wastes, and kelp. Attention was first directed to the prospects of natural deposits whose origin and character might bear some resemblance to the German deposits. The existence of such deposits presents two possibilities, "those of marine origin, as typified by the German deposits resulting from the evaporation of great volumes of sea water which had been cut off from the main body of the ocean through the formation of bars or reefs; and those of inland or continental origin, typified by the various salt lakes and surface saline

Wroth, J. S., p. 124

deposits resulting from the evaporation of inland seas or lakes."[1] The latter were known to exist in several localities, particularly in the West. Knowledge of deposits of the former type was extremely limited, although government research revealed a few beds of such origin. The salt mine strata, underlying the states of New York, Pennsylvania, Ohio, Michigan, Kansas, and Louisiana were analyzed for traces of potash but the tests failed to show any conclusive evidences. Experiments made in Texas, however, were more encouraging, as substantial quantities had been discovered early in 1912 by J. A. Udden, Director, Bureau of Economic Geology and Technology of the University of Texas.[2] These early indications of potash-bearing salts formed the basis of further investigations carried on by the Geological Survey. Samples obtained of the underground strata indicated definitely the presence of polyhalite and sylvinite, but the samples themselves were unreliable because of the inadequacy of the churn-drills or rotary outfits used. There was no way of discovering the extent of individual beds because the possibility of mixing materials in the churning process confused estimates of the extent of underlying deposits. Moreover, seepage of water presented another difficulty,

1. Turrentine, J. W., "Potash", p. 64
2. " " p. 161

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for its reaction on the salts tended to either strengthen or weaken their potash properties, according to the solubility of the salts. With the methods at hand, however, prospectors could not be sure. The findings in Texas at this time, in spite of promising results, could be nothing more than suggestive.

Surface brines in the salt lake areas of several western states showed better prospects for immediate potash recovery. In Western Nebraska there were a number of small, shallow lakes containing large quantities of potassium and sodium salts. While the actual amounts were relatively small, the quality of the brine was high enough to warrant exploitation during the War. The shipments made from this source were generally in the form of crude unrefined salts that "had been pumped to the mill",[1] "evaporated down to wet salts in vacuum pans"[1] and "passed through rotary driers"[1] in the final stage for the market. The high freight costs on the non-potash elements of these salts could be borne only in the desperation of war time deficiency which, in addition to the inadequacy of the supply, explains the reason for their abandonment after the war. The brines of several other salt lake regions were ana-

1. Yearbook of the Dept. of Agriculture, 1916, "Importance of Developing Our Natural Resources of Potash",(F. W. Brown), p. 307

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lyzed, including the Salduro Marsh Brine, the Great Salt Lake Brine in Utah, the Banneville Basin in Utah and Nevada, and the Searles Lake Brine in California. Small quantities of potassium salts of low concentrations found in the Banneville Basin were negligible. In the Salduro Lake section of Utah, 110 miles west of Great Salt Lake, a source of potassium chloride was revealed in the winter brine which evaporated in summer to a salt crust, three inches thick. Its potash content was high enough to justify war-time exploitation by the Salvoy Process Company but, because of limited quantities and the great distance from markets, this plant was abandoned immediately after the War. In the Great Salt Lake area of Utah, tremendous amounts of the raw material were available, but extremely low potash content and the difficulty of extraction discouraged the continued development of all the brine sources by the Salt Lake Chemical Company and the Utah Chemical Company. Searles Lake, California, was the most promising and most significant territory. The lake, situated in the heart of a desert basin consists of a main salt body, eleven miles square and sixty feet thick, which is permeated with a brine containing about 2.5% of actual potash.[1] Below the salt flat

1. Stocking, G. W., Foot-note, p. 303

there is an underlying strata of mud and salts. Most of the potash exists in the brine, although there are scattered traces that have settled in the salt strata. As early as 1911, production was begun by the American Trona Company which was dissolved, a second one taking its place. The second plant, operating under its original name, became the American Potash and Chemical Corporation, today "the single striking example of a successful large-scale American producer of potash."[1] A potential capacity estimated at twenty million tons of potash was present in the Searles Lake Brine, a supply which would last for eighty years at the present rate of consumption.[2] During the War, this lake supplied the bulk of American production which managed to fulfill one-fifth of domestic requirements; after the War, it was one of the two survivors of a post-war deflation in the industry.

Besides the Salt Lake Brines in Utah, native mineral sources of potash were found in the alunite deposits near the Marysvale district. The mineral was classified as an "aluminum-potassium sulphate,[3] from which potash and aluminum could be obtained after a preliminary roasting process. Production from the alunite mines could be commercially success-

1. Stocking, G. W., Foot-note p. 303.
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ful only by concentrating on the alumina as a major product and extracting potash as a by-product. This arrangement would necessitate assurance of a definite aluminum market.[1] Transportation through mountainous country and high freight rates to markets presented further difficulties which were, however, subordinated during the War when potash from any source and at any price seemed commercially feasible. Likewise, the Geological Survey encountered similar geological and economic difficulties arising in the production of potash from leucite in Wyoming. This mineral, popularly called "wyomingite", exists as a "silicate of alumina and potash"[2] with a potash content slightly higher than alunite, Although it was pronounced by Mr. Roger C. Wells of the Department of Interior as a mineral richer in potash than feldspar, a recognized high potash-bearing mineral, the probabilities for profitable exploitation were slight. As for feldspar, itself, in spite of its high potash con- and wide occurrence, tests have shown that it would be impracticable for commercial purposes.

As the investigation progressed, considerable enthusiasm was demonstrated in regard to the possibilities of kelp as a source of potash. Along the Pacific Coast kelp exists as an enormous seaweed,

1. Turrentine, J. W., "Potash", p. 85
2. U. S. Geological Survey Bulletin, No. 98-D. 1916 Experiments on the Extraction of Potash from Wyomingite", p. 37

growing sometimes to a length of one hundred feet and containing in its dried form as much as 25-30% of potassium chloride. Sufficient quantities were found to guarantee an almost inexhaustible supply. Its value was particularly stressed because of the presence of several potential by-products in the form of iodine, ammonia, and tar products. Furthermore, experiments showed that a decolorizing carbon obtained from the charcoal residue in the process of distillation could be a large factor in reducing costs of separating the potash. Excess transportation costs on worthless material, however, and the lack of an efficient and profitable method of extraction have eliminated the prospects of developing potash from kelp on an important scale. Although the government erected an experimental plant in 1917 at Summerland, California, private enterprise, unimpressed by the data collected, failed to develop kelp either in connection with potash or its by-products.

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The greensands, found largely in New Jersey, constituted an abundant source of potash material, fairly uniform in occurrence, easy to mine, and in an advantageous position in respect to markets. Nevertheless, a low potash content and the lack of by-product material frustrated any attempts to develop these deposits commercially. The other potential eastern source, the soft easily-mined slates of Georgia, containing from 8 to 9% of potash, also gave promise at first of commercial exploitation and stimulated added interest because of their strategic location in the great potash-consuming area of the South. Once more it was a question of by-products, which, though present in the shales, was of a nature that could be absorbed only in the cement industry.

Among trade wastes, the cement industry offered an opportunity of recovering potash from cement flue dust. Feldspar deposits and Georgia silicates supplied the necessary material for this method of production, whereby the potash originally in insoluble form, could be produced as a by-product and the cement as a major product. In the United States Agriculture Yearbook for 1916, Mr. Frederick Brown, in charge of investigating fertilizer resources for the Bureau of Soils, describes briefly the process

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the total 63,880 tons produced in 1931.[1]

In spite of the encouraging nature of the data collected by the Geological Survey and Bureau of Soils Agencies, none of the domestic sources were developed until the outbreak of the War. In 1914, American imports showed the highest figures on record, totalling 1,085,004 tons of potash, valued at $16,350,019.[2] When the German embargo of 1915 suddenly cut off this supply, every available source of potash disclosed by the government surveys was utilized. Production at Searles and the Nebraska Lakes accelerated, and recovery in smaller amounts was made from blast furnace dust, cement dust, silicate rocks, alunite, greensands, distillery or sugar refinery wastes, wood ashes, and kelp. Prices soared, mounting 130% higher than the pre-war level.[3] As a result, high-cost producers were eligible for profitable business. Muriate of potash, which in December, 1913, sold for $39.00 a ton, rose to $500.00 a ton in December, 1915.[4] By 1918, domestic production totalled approximately 200,000 tons of crude salts with an actual potash content of 55,000 tons representing one-fifth of the amount consumed before the War. Stimulated by high prices, the expansion of the domestic industry was rapid, as illustrated by the

1. U. S. Dept. of Commerce, Potash in 1931, A.T. Coons
2. U. S. Tariff Commission Bulletin, 1919, "Information Concerning the Potash Industry", p. 11.
3. Business Week, February 25, 1931, "Four Native Sources May Free Us from European Potash", p. 34.
4. Brown, F. S., p. 310

following table:[1]

YEAR	NO. OF PRODUCERS		PRODUCTION	
	Total	Exclusive of producers of wood-ash potash	Crude Salts	K_2O Content
			Short tons	Sh. tons
1915	5	5	4,374	1,090
1916	70	25	35,739	9,720
1917	95	46	126,961	32,573
1918	128	77	207,686	54,803

After the War, domestic production sharply declined. In 1919, domestic fertilizer companies withheld orders in anticipation of renewed German imports. The abrupt cancellation of orders forced the majority of concerns out of business. Those producers who managed to drift along in the hope of protective governmental measures that were never realized finally succumbed to the severe business depression of 1921. Obviously, with a return to normal, high cost of processing and high freight rates to markets, caused the collapse of the American industry. Only two companies were able to weather the storm; the United States Industrial Chemical Plant, which produced potash as a by-product, and the American Potash and Chemical Corporation, whose production costs

1. Wroth, J. S., "Commercial Possibilities of the Texas-New Mexico Deposits", p. 125.

were borne largely by its by-product, borax.

Of the two companies which survived, the American Potash and Chemical Corporation at Searles Lake, California, was by far the more important. After the War, it continued as the largest, individual producer of American potash, supplying in 1927, 85% of the entire American output.[1]

The plant site of the company is situated on Searles Lake at Trona, in an arid desert region about 165 miles from San Francisco. In former days, the lake received the waters of a river on the north, whose course has since been deflected, leaving the lake unattached and exposed to intense solar evaporation. At present, only a relatively small amount of water flows into the lake. With much of the water absorbed, a mass of crystalline salts formed, saturated with a brine, which in summer settles a few inches below the salt level, and in winter rises a few inches above it. The surface crust is smooth, and solid enough to hold a pump house through which pipes transmit the brine from the crystalline structure to the plant. The brine contains a variety of chemical elements which are given, according to percentages in the following data:[2]

1. World Conditions as to Mineral Raw Materials for the Fertilizer Industry - Published by the National Fertilizer Association, 1926, p. 86
2. Taken from a pamphlet published by the American Potash and Chemical Corporation for 1928.

Searles Lake Brine

Common Name	Chemical Name	% By Weight
Common Salt	Sodium Chloride	16.35
Salt Cake	Sodium Sulphate	6.96
Muriate of Potash	Potassium Chloride	4.75
Soda ash	Sodium Carbonate	4.74
Borax	Sodium Tetraborate Dekahydrate	2.86
Miscellaneous		.47
	Total Salts (Approximately)	36.13
	Water	63.87
		100.00

When the brine enters the plant from the pipe lines, it is fed into triple-effect evaporators, so-called, because of the three distinct operations performed. The process of manufacture involves a fractional crystallization method whereby the various elements are crystallized out at different temperatures. At the lower temperature, the less valuable elements of sodium chloride, sodium sulphate, and sodium carbonate are precipitated, and, after being deposited on pans, are washed back to the lock through a sewer. In the second stage, with further applications of steam to increase the temperature, potassium chloride begins to crystallize out. It is rapidly removed from the liquor and deposited on

settling pans. This deposited mass is next run into centrifugals which,in the process of spinning, separate the salts from the liquor. Finally, the potash product is ready for market after sufficient washing and drying.

The next step is to recover borax from the liquor which has liberated potassium chloride. In this process there are two stages of crystallization. The first stage recovers most of the borax from the mother liquor by carbonization. In the second stage, the borax so obtained is recrystallized, a procedure which refines the borax product to the very highest degree of purity. Finally, a bone-dry, exceedingly high quality product is ready to be sacked and shipped to market.

The American Potash and Chemical Corporation developed from a small, crudely-operated borax company to the present, large-scale plant,turning out approximately 240 tons of potassium chloride and 130 tons of borax per day.[1] About 1870, John Searles, one of the pioneer prospectors in the West, discovered and produced borax from the marginal lake crusts in the valley which bears his name. The output was small; the quality, poor; and the transportation charges, all out of proportion to the returns. Production by

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the Searles Company, known as the San Bernardino Borax Company, continued until 1895; then operations subsided and finally petered out. Interest in borax mining at Searles Lake was not renewed until 1905 when the California Trona Company made claims in the lake. Following a series of surveys and experiments in 1912, commercial developments of the potash and borax in the lake were begun by the California company, which later passed into the hands of a new company known as the American Trona Corporation. Between 1913 and 1915, improvements were made to reduce operating costs - a trunk railroad was constructed connecting Searles with Trona, the last stop on the Southern Pacific, and, in addition, a new experimental plant was completed. The erection of a second plant followed in 1916, marking the foundation of the American Potash and Chemical Corporation at Trona. Even though complex engineering and chemical problems confronted the industry at Searles, the war-time boom carried the company along on high profits, despite exorbitant production costs and inefficiency of operations. After the War, the Searles Lake project escaped the fate of hundreds of other potash plants that were snuffed out by vigorous foreign competition; it did not escape, the Searles Company, known as the San Bernardino Borax Company, continued until 1895; then operations subsided and finally petered out. Interest in borax mining at Searles Lake was not renewed until 1905 when the California Trona Company made claims in the lake. Following a series of surveys and experiments in 1912, commercial developments of the potash and borax in the lake were begun by the California company, which later passed into the hands of a new company known as the American Trona Corporation. Between 1913 and 1915, improvements were made to reduce operating costs - a trunk railroad was constructed connecting Searles with Trona, the last stop on the Southern Pacific, and, in addition, a new experimental plant was completed. The erection of a second plant followed in 1916, marking the foundation of the American Potash and Chemical Corporation at Trona. Even though complex engineering and chemical problems confronted the industry at Searles, the war-time boom carried the company along on high profits, despite exorbitant production costs and inefficiency of operations. After the war, the Searles Lake project escaped the fate of hundreds of other potash plants that were snuffed out by vigorous foreign competition; it did not escape, however, considerable loss and the necessity for immediate improvements in operation. By 1925, the effect of improvements on profits was reflected in the production figures of the company as follows:[1]

YEAR	TONS POTASH	TONS BORAX
1917	14,730	
1918	21,319	
1919	9,583	1,937
1920	9,629	4,643
1921	6,780	3,206
1922	14,229	5,982
1923	26,831	13,363
1924	32,153	15,810
1925	36,308	17,447

Thereafter profits and production continued to rise, so that by 1928, the plant was producing annually 90,000 tons of potash and 48,000 tons of potash in round figures, representing a profit for the first six months in 1928 of $782,237.18.

Coincident with the development of potash in the Death Valley region of California was the development of borax, not only as a by-product of the lake brines, but as a separate mining enterprise

1. American Potash and Chemical Co. Bulletin - 1928.

based on deposits of borate of lime found in the Funeral and Calico Mountains. Independent development of borax in the mountains unquestionably had its effect upon the American Potash and Chemical Company whose high production costs from the very beginning were supported by borax recovered as a by-product. In 1872, Francis Marion Smith, an energetic valley prospector, had discovered large quantities of borax in Teele's Marsh, Nevada. Smith was later to be known as "Borax Smith", founder of the widely-advertised "Twenty Mule Team Borax." Smith's small company absorbed the claims of another borax owner, but in spite of the addition, there were many difficulties to retard its progress. The borax had to be hauled many miles through desert wastes to the railroad by mule teams; a slow, expensive, cumbersome means of transportation. Later, however, the company expanded and grew rich on the new mineral deposits discovered in the mountains nearby. As a result, the mules were abandoned, a company railroad was built, and the production of borax rose rapidly. In 1899, the Smith company merged with Borax Consolidated - a large international British-owned group, operating under the new name of Pacific Coast Borax.

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The Texas-New Mexico-potash beds are associated with the vast Permian[3] Salt Basin, extending northwest from western Texas and southeastern New Mexico across western

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2. Business Week, April,15, 1931,"Britain Gets Control; We Still Have the Potash".
3. A name given to the closing era in the Carboniferous Age in geological history.

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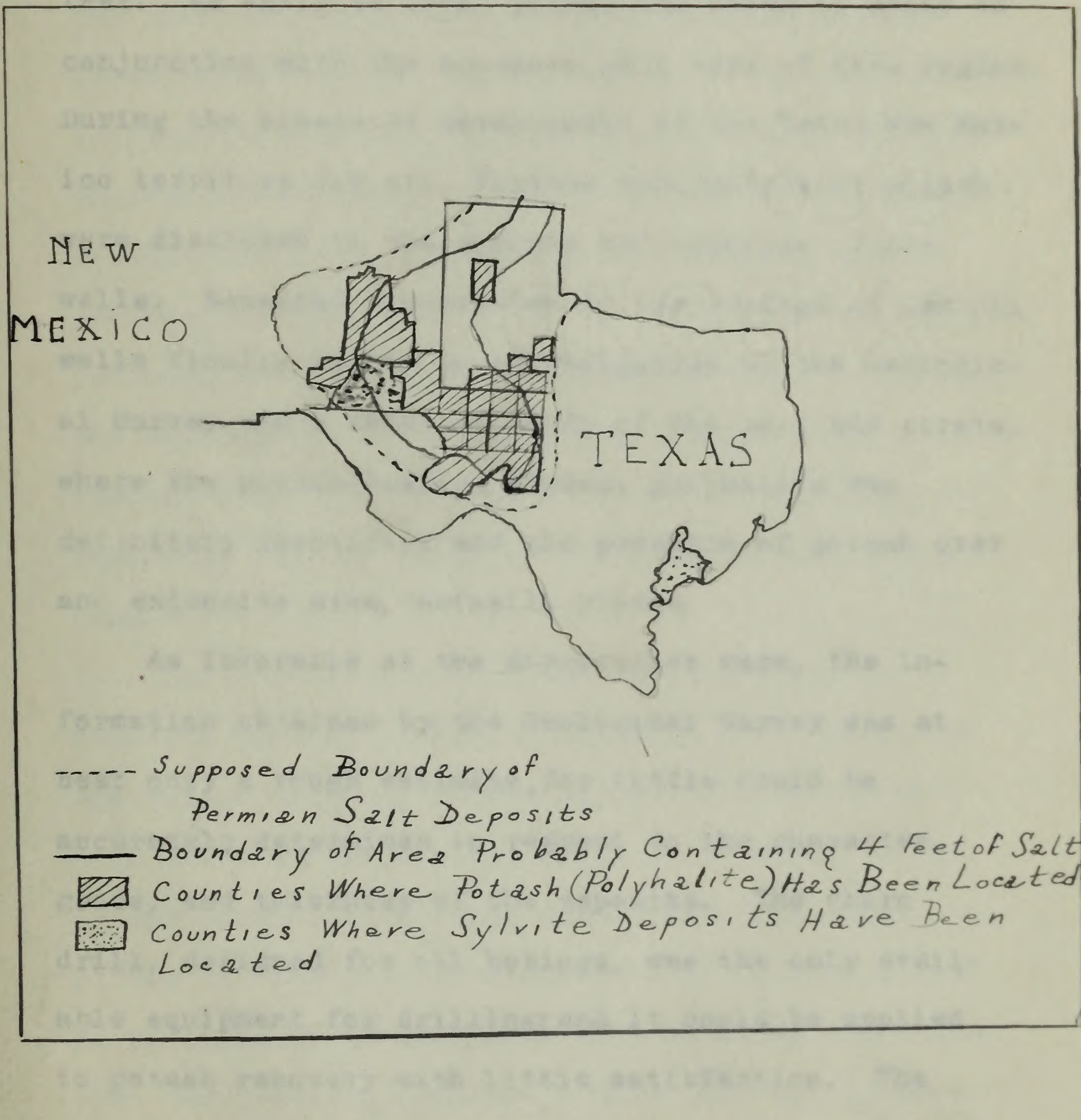
NEW
MEXICO
TEXAS
----- Supposed Boundary of Permian Salt Deposits
——— Boundary of Area Probably Containing 4 Feet of Salt
Counties Where Potash (Polyhalite) Has Been Located
Counties Where Sylvite Deposits Have Been Located

Oklahoma into central Kansas. This basin contains the greatest salt field in the world, possessing salt deposits estimated at 30,000 billion tons.[1] An area of approximately 70,000 square miles covers the entire salt formation whose average thickness is about 1,000 feet. As early as 1912, potash was known to exist in conjunction with the enormous salt beds of this region. During the intensive development of the Texas-New Mexico territory for oil, further indications of potash were disclosed in the sludges and cuttings of the wells. Repeated discoveries in the borings of new oil wells finally led to an investigation by the Geological Survey and a detailed study of the salt bed strata, where the potash-bearing mineral polyhalite was definitely identified and the presence of potash over an extensive area, actually proved.

As favorable as the discoveries were, the information obtained by the Geological Survey was at best only a rough estimate,for little could be accurately determined in respect to the character, grade, and thickness of the deposits. The churn drill, designed for oil borings, was the only available equipment for drilling;and it could be applied to potash recovery with little satisfaction. The results of the investigations, however, were prompt-

1. Hoar, H. M. p. 85

ly published by the government in the hope of stimulating private capital to enter the field and develop the deposits by core drilling. Through the core-drill method, deposits can be accurately examined and the exact geological formations easily determined. With the exception of a few sporadic and unsuccessful attempts on the part of oil companies and drillers to prospect the salt beds by core-drilling, private capital hesitated to invest in a project which seemed at the time commercially unjustifiable, on the grounds that costs would be too high to permit competition with the low-cost German product. Likewise, the information at hand was inconclusive, and after the War a collapse of the industry did anything but encourage capital into the field of potash development.

Definite interest in the Texas-New Mexico deposits was not resumed until 1926 when the Standard Potash Company, after completing a series of core tests struck a rich, mineable layer of potash in the southwestern Texas area. The cores were submitted for analysis to Professors E. P. Schoch and E. H. Sellards of the University of Texas who found that the deposits composed a five foot bed of pure polyhalite at a depth of 2,075-2,080 feet. The enly published by the government in the hope of stimulating private capital to enter the field and develop the deposits by core drilling. Through the core-drill method, deposits can be accurately examined and the exact geological formations easily determined. With the exception of a few sporadic and unsuccessful attempts on the part of oil companies and drillers to prospect the salt beds by core-drilling, private capital hesitated to invest in a project which seemed at the time commercially unjustifiable, on the grounds that costs would be too high to permit competition with the low-cost German product. Likewise, the information at hand was inconclusive, and after the War a collapse of the industry did anything but encourage capital into the field of potash development.

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All through this early period of prospecting, the government, through the agency of the Bureau of Mines, was likewise active in core-drilling, as well as core analysis. After sinking sixteen wells, government workers found deposits of polyhalite in

1. Stocking, G. W., "The Potash Industry", p. 301

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every well; some of slight economic significance, others, rich enough in potash content to justify commercial exploitation. One extremely rich bed, occurring at a depth of 1405 feet, was composed of polyhalite eight feet thick, three feet three inches of which was pure, with an average potash content of 12.21%. Finally, the facts disclosed by the drilling activities of both the government and private enterprise led to definite generalizations concerning the Texas-New Mexico deposits. It developed that the American Permian basin belonged to the same age as the Permian basin in Germany, although the American area of 70,000 square miles is almost three times as large as the German. Polyhalite appeared in scattered beds throughout the entire region, indicating a series of individual deposits limited in extent by the boundaries of the basin or lagoon where the brine had evaporated and deposited the salt residue. The most valuable beds, however, were in the western portion of these large salt basins in Texas and New Mexico. In general, the deposits lay nearer the surface than the German, occurring at a depth of from 500 feet to more than 2700 feet, with the richest salts near the 1,000-foot level. In contrast, German deposits merely begin at every well; some of slight economic significance, others, rich enough in potash content to justify commercial exploitation. One extremely rich bed, occurring at a depth of 1405 feet, was composed of polyhalite eight feet thick, three feet three inches of which was pure, with an average potash content of 12.21%. Finally, the facts disclosed by the drilling activities of both the government and private enterprise led to definite generalizations concerning the Texas-New Mexico deposits. It developed that the American Permian basin belonged to the same age as the Permian basin in Germany, although the American area of 70,000 square miles is almost three times as large as the German. Polyhalite appeared in scattered beds throughout the entire region, indicating a series of individual deposits limited in extent by the boundaries of the basin or lagoon where the brine had evaporated and deposited the salt residue. The most valuable beds, however, were in the western portion of these large salt basins in Texas and New Mexico. In general, the deposits lay nearer the surface than the German, occurring at a depth of from 500 feet to more than 2700 feet, with the richest salts near the 1,000-foot level. In contrast, German deposits merely begin at the 1200-foot level. An average thickness of six feet of the American polyhalite does not compare as favorably with the German beds but approaches more nearly the French deposits as to thickness and regularity. Therefore, although the beds are more shallow than the German, the potash content occurs in more concentrated form. In answer to many queries on this phase of the project, the Bureau of Mines gives emphatic assurance that the comparative shallowness of the American polyhalite beds present no handicap to efficient mining and drilling.

When oil prospectors discovered sylvite in Texas and New Mexico, it was the first time that a chloride salt appeared in this new exploratory region where sulphates seemed to predominate. The sylvite beds include a zone of 254 feet, extending from an upper level of 1212 feet below the surface to a lower level of 1466 feet and representing a rich block of highly soluble chlorides. German and French chlorides, on the other hand, average from 150-250 feet. Had the New Mexico sylvite beds proved extensive, the problem of developing a profitable American potash industry would have been immediately solved. Of all the potash-bearing minerals,

sylvite contains the highest percentage of pure potash, amounting theoretically to 63.2% K_2O, while kainite, carnallite, and polyhalite have a corresponding theoretical K_2O content of 18.9, 16.9, and 15.6% respectively.[1] In Alsace, sylvite deposits constitute almost exclusively the entire potash production. Unfortunately, however, the New Mexico sylvite exists only in a few small mines in too limited quantities to be of any great economic importance. This does not mean that possibilities for rich sylvite deposits in New Mexico are slight. On the contrary, the very uncertainty as to what treasures the earth might hold will be an important factor in sustaining a relentless search for sylvite in this region - just as it was in Germany. Already, a company near Carlsbad, New Mexico, the first pioneer in actual potash mining, has made important contributions to American production. According to the latest report by the Department of Commerce "an increase of 26.6% in the quantity of salts produced in 1931 is due to the inclusion of material from a recently opened deposit of potassium salts at Carlsbad, New Mexico."[2] It is possible that New Mexico possesses an abundance of sylvite as yet undiscovered.

Inasmuch as the mining of the Texas-New Mexico

1. Commerce Monthly, "The Possibilities of an American Potash Industry", December, 1928.
2. U. S. Dept. of Commerce, "Potash in 1931", A. T. Coons, p. 23.

deposits has an advantageous outlook, the refining of the salts contains some real problems. American polyhalite is a chemical compound and not a mechanical mixture like the German salts; hence, it is practically insoluble in water. If this mineral were found in a sufficiently pure state, it could be ground and used directly as a fertilizer, but a growing tendency on the part of American consumers to demand potash salts in more concentrated form requires some method of processing before the product can be placed on the market. Already, the Geological Survey has found such a process, of German origin, which is particularly applicable to the refining of polyhalite. Since the compound itself has a different chemical energy than the constituents, namely, the sulphates of potassium, magnesium, and calcium, the various elements must be broken down by a heating process at high temperature. In this first step, the potassium and magnesium sulphate go into solution and the calcium sulphate remains undissolved. After the calcium is filtered, an evaporation process intensifies the concentration of potassium sulphate in the remaining solution. In its final form the salt is recovered as a mixture of potassium sulphate and magnesium sulphate known as "schonite" and marketed as a "double sulphate of deposits has an advantageous outlook, the refining of the salts contains some real problems. American polyhalite is a chemical compound and not a mechanical mixture like the German salts; hence, it is practically insoluble in water. If this mineral were found in a sufficiently pure state, it could be ground and used directly as a fertilizer, but a growing tendency on the part of American consumers to demand potash salts in more concentrated form requires some method of processing before the product can be placed on the market. Already, the Geological Survey has found such a process, of German origin, which is particularly applicable to the refining of polyhalite. Since the compound itself has a different chemical energy than the constituents, namely, the sulphates of potassium, magnesium, and calcium, the various elements must be broken down by a heating process at high temperature. In this first step, the potassium and magnesium sulphate go into solution and the calcium sulphate remains undissolved. After the calcium is filtered, an evaporation process intensifies the concentration of potassium sulphate in the remaining solution. In its final form the salt is recovered as a mixture of potassium sulphate and magnesium sulphate known as "schonite" and marketed as a "double sulphate of potash magnesia."[1] Naturally, the item of expense in this process is the prolonged heating which is necessary in several stages before the potassium sulphate can be secured in concentrated form. This does not indicate, however, that the difficulties are impossible to overcome, for a minimizing of other costs, such as wages, capital charges, mining expenses, and transportation, as well as efficient management and organization, may counteract the disadvantages of high fuel charges.

Since the difficulties of refining polyhalite can be undoubtedly surmounted, the next question is to determine whether or not American consumers will absorb domestic sulphates in quantities sufficient to justify commercial exploitation of the polyhalite mines, or whether they will continue to prefer German chlorides. This leads to a consideration of the present American consumption in terms of grades and types preferred. It is known that American consumers buy potash interchangeably as crude salts, as highly concentrated salts, or as a mixed variety of both. Recently, refined salts have enjoyed increasing preference, particularly in the American market where high freight rates have to be considered. The following data classifies the various salts consumed in the

1. Stocking, G. W., "The Potash Industry", p. 310

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1. Stocking, G. W., "The Potash Industry", p. 310

United States into three groups, "refined", "mixed", and "crude", defining each individual salt according to its potash content:[1]

A. REFINED SALTS:

1. Muriate of potash (KCl) - "Muriate of potash is a potash salt containing not less than 48% of potash (K_2O), largely as a chloride."

2. Sulphate of potash (K_2SO_4) - "Sulphate of potash is a potash salt containing not less than 48% of potash (K_2O), largely as a sulphate, and not more than 2.5% of chloride."

3. Sulphate of potash-magnesia (K_2SO_4 $MgSO_4$); also known as a double manure salt. "Sulphate of potash-magnesia is a potash salt containing not less than 25% of potash (K_2O), nor less than 25% of sulphate of magnesia, and not more than 2.5% of chlorine."

B. MIXED SALTS:

Manure or fertilizer salts - "Manure salts shall be understood to mean potash salts containing a high percentage of chloride and from 20 to 30% of potash (K_2O)." These are marketed in two standard grades:

1. Wroth, J. S., p. 27

1. Thirty per cent manure salt.

2. Twenty per cent manure salt.

C. CRUDE SALTS:

Kainite:- "Kainite is a potash salt containing potassium and sodium chlorides and sometimes sulphate of magnesia, with not less than 12% potash (K_2O)."

Additional information in the Department of Commerce Bulletin for 1930, No. 316, indicates that American consumers at present absorb chloride salts in larger quantities than any other potash salt, as shown by the table below:[1]

Consumption of Potash Salts in U. S. (1930)

NAME OF SALT	PERCENTAGE CONSUMED
Muriate of Potash (Refined KCl)	39
Sulphate of " (Refined K_2SO_4)	16
Sulphate of Pot-Magnesia	1.3
Manure Salts	34
Kainite	5
Miscellaneous	4.7
	100.0

The reason for the predominance of chlorides in the American market is obvious. In Germany and France, chloride salts prevail generally, occurring as natural

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deposits. The Germans derive muriates largely from hartsalz and carnallite, while the French muriates come from crude sylvite. In the United States, the largest American producer at Searles Lake deals almost exclusively in muriates obtained from the lake brine. Likewise, these same sources yielding chlorides also furnish manure salts, produced whereever potash exists as potassium chloride. Imported sulphates, on the other hand, do not occur as natural deposits, but result from an artificial treatment process in which high-grade refined potassium chloride is mixed with refined kieserite - magnesium sulphate - to yield potassium sulphate and magnesium chloride. Another process yields sulphate of potash by treating potassium chloride with sulphuric acid. Consequently, the very fact that foreign producers manufacture sulphates in order to satisfy specific demands of American consumers reveals the importance of these salts in the American market. Furthermore, the percentage of sulphates sold in the United States is relatively high, considering the natural limitations of present producing areas. An urgent necessity for the replacement of sulphates for chlorides in the Southern States - if the crops are to attain the highest degree of perfection and marketability - justifies a wide exdeposits. The Germans derive muriates largely from hartsalz and carnallite, while the French muriates come from crude sylvite. In the United States, the largest American producer at Searles Lake deals almost exclusively in muriates obtained from the lake brine. Likewise, these same sources yielding chlorides also furnish manure salts, produced wherever potash exists as potassium chloride. Imported sulphates, on the other hand, do not occur as natural deposits, but result from an artificial treatment process in which high-grade refined potassium chloride is mixed with refined kieserite - magnesium sulphate - to yield potassium sulphate and magnesium chloride. Another process yields sulphate of potash by treating potassium chloride with sulphuric acid. Consequently, the very fact that foreign producers manufacture sulphates in order to satisfy specific demands of American consumers reveals the importance of these salts in the American market. Furthermore, the percentage of sulphates sold in the United States is relatively high, considering the natural limitations of present producing areas. An urgent necessity for the replacement of sulphates for chlorides in the Southern States - if the crops are to attain the highest degree of perfection and marketability - justifies a wide expansion of the American sulphate market.

Since polyhalite will yield as major products, sulphate of potash and sulphate of potash magnesia, in addition to a minor product containing a mixture of potash, magnesia, and lime, it is necessary to consider the present and the potential possibilities for sulphates in American agriculture. Fruit growers of the South have already recognized the superiority of sulphate of potash in improving the flavor and quality of citrous fruits, and as a result have made extensive use of this particular salt in the orange and lemon groves of California and Florida. Sulphates are equally important to tobacco crops but high prices have so completely discouraged tobacco growers in the past that they have preferred to contend with mediocre crops, using the cheaper chlorides rather than employ the more expensive sulphate fertilizer, which would insure healthier crops. This situation is gradually being eliminated, and, with the appearance of cheaper American sulphates, will, no doubt, be entirely eliminated in the future. Although tobacco requires small amounts of chloride to invigorate the plant, increase the yield, and provide resistance to draught, excessive chlorine retards its growth and destroys the free-burning quality of the pension of the American sulphate market.

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The elements of magnesia and lime should, also, be essential ingredients of tobacco fertilizer. For a long time, the thin colorless condition of the leaves growing on the light sandy soils of the South was attributed to a disease common to tobacco plants. Experiments recently traced this crop malady to "magnesia starvation" which can be prevented by applying magnesium to the soil. Magnesia alone, however, has a peculiar toxic effect on plants, that is, while it stimulates vigorous growth, the plants develop to abnormal proportions, maturing very often as "freaks". Additions of lime to magnesia in the fertilizer counteract this condition, promoting healthy, normal advancement of the plant.

There is no question as to the excellence of the polyhalite products in supplying in a natural combination, the elements of sulphate of potash, magnesium,

1. Wroth, J. S., p. 24

and lime essential to the proper cultivation of tobacco plants. A demand for these products also exists in other crops besides tobacco and citrous fruits, chiefly cotton and corn. Undoubtedly, a lowering in the production costs of Texas-New Mexico polyhalite will establish sulphates at reasonable prices, low enough to supersede German chlorides in many areas, and to create an active, increasing demand for the American product.

With an adequate supply and an enormous domestic market definitely assured, the element of cost continues to remain, at present, the one great factor preventing an immediate realization of a large-scale American potash industry. An analysis of comparative costs in the German and American industries by the Bureau of Mines decidedly favors the American industry, based on the mining and refining of polyhalite in Texas and New Mexico. Computations by the Bureau, given in table form, are as follows:[1]

1. Stocking, G. W., p. 317

A Comparison of the Average Cost per Metric Ton of K_2O for the enumerated Factors in the German Potash Industry in 1928 with Estimates of Similar Costs for An American Industry Based on Polyhalite

	GERMAN INDUSTRY	AMERICAN INDUSTRY
Labor Costs	$8.10	$8.10
Fuel and Power	2.97	11.55
Other Operating Expenses	8.17	4.71
Depreciation	8.57	5.06
Supervision & Administration	3.48	4.13
Taxes	1.52	----
Int. on Bonded Indebtedness	2.67	----
Cost of Works Closed down	1.67	------
Total Cost	$37.15	$33.55

Professor Stocking questions the accuracy of several items in the Bureau's estimate, on the grounds of judgment rather than any misrepresentation of figures. A tendency on the part of the German industry to expand actual costs in order to disguise profits, and the opposite tendency by the Bureau of Mines to minimize and even eliminate charges have resulted in a wide discrepancy, giving the American industry an unwarranted advantage. Professor Stocking suggests an alteration of several items in both the German and American estimates, as follows:

ALTERATIONS IN GERMAN ESTIMATES:

1. A 2½% deduction in wages to offset labor charges on "extensions and betterments" inappropriately considered as a production cost.
2. An elimination of "expenditures for improvements and betterments" from "other operating expenses", interpreting the former as a reabsorption of profits into the business.
3. A decrease in "depreciation charges" which in 1928 amounted to 17.53% of book value as opposed to the usual conservative estimate of from 5 to 15%.[1]
4. An arbitrary deduction in "cost of works closed down", because payments made to subsidiaries were merely bookkeeping transactions due to depreciation of the mark. Later, the subsidiaries were reabsorbed by parent companies.

ALTERATIONS IN AMERICAN ESTIMATES:

1. An inclusion of royalty payments to lessors.
2. A charge of 54¢ to cover inevitable county, state, and federal taxes omitted by the Bureau.

Such changes seem logical and conservative. In fact, Professor Stocking does not include interest charges on capitalization that will unquestionably

1. Professor Stocking believes that an increase in depreciation charge in 1928 to 17.53% from the 1926 charge of 10.34% indicates an attempt to conceal hidden assets.

become an item of expense if the industry is to be developed on an important commercial basis. Likewise, the fact that the American industry will probably be composed, at the beginning, of a number of small plants rather than of large consolidations now formed in the German industry, promises additional expenditures. Notwithstanding the exclusion of these charges, Professor Stocking's revised estimate gives a narrow margin of advantage to the German industry, shown as follows:

Corrected Comparison of the Average Costs per Metric Ton of K_2O for the Enumerated Factors in the German Potash Industry in 1928 with Estimates of Similar Costs for an American Industry Based on Polyhalite

	GERMAN INDUSTRY	AMERICAN INDUSTRY
Labor Costs--------------	$7.90	$8.10
Fuel & Power-------------	2.97	11.55
Other Operating Expenses-	5.24	5.21
Depreciation-------------	5.83	5.06
Supervision & Administration-	3.48	4.13
Taxes--------------------	1.52	.54
Interest on Bonded Indebtedness-	2.67	----
Cost of Works Closed Down--------	.67	----
Total-----------	$30.28	$34.59
Selling Espense----------	7.46	3.46
Total Cost-----------	$37.74	$38.05

Should American potash prove capable of competing favorably with German potash in respect to production costs, comparative freight rates would be unquestionably the last deciding factor in the endorsement of an American industry. In the present area of consumption, the southeastern states, Germany has the advantage, because of low ocean freights as compared with the high land freights. As the imported product moves inland, potash from New Mexico would benefit owing to a progressively lower freight rate. A tabulation of comparative freights clearly illustrates this point:

DESTINATION	TRANSPORTATION CHARGES FOR GERMAN INDUSTRY PER SHORT TON	TRANSPORTATION CHARGES FOR AMERICAN INDUSTRY PER SHORT TON
To Atlantic ports:		
1)Chlorides or mixed salts	4.73	10.95
2)Sulphates		12.20
To Gulf ports:		
1)Chlorides or mixed salts	4.73	8.00
2)Sulphates		8.00
To interior southern states:		
1)Chlorides or mixed salts	9.08	8.50
2)Sulphates		9.40
To interior central states:		
1)Chlorides or mixed salts	11.73	9.15
2)Sulphates		10.

It is obvious from these figures that a Texas-New Mexico industry would have the best chance of competing with the German industry in the territory of the central states and the poorest chance in the southern states. There are two possibilities of overcoming this disadvantage:

1) By creating a new market in the central states by effective propaganda
2) By obtaining freight concessions on large shipments of potash.

VI. Conclusion

Any conclusions as to the future of an American Potash Industry can be only in the nature of a prophecy. Its realization at present depends on the success of the Texas-New Mexico venture, based on the exploitation of polyhalite. The success of this new American project, in turn, will depend upon the adoption of a refining process which can extract the potash at costs low enough to compete favorably with the German product. It is said that Professor E. P. Schoch of the University of Texas has perfected such a process which he will submit for tests as soon as patents are secured. In the event of such improvements, plus rigid economies in other cost items and intelligent managerial direction, the industry is substantially equipped to proceed at once with commercial operations. In every case, the prospects for sylvite are more reassuring because of richness of deposits, easy accessibility, and low refining costs. As yet, the quantities of sylvite are scarce and the information concerning newer beds, inconclusive.

It is to be remembered, however, that American potash is being developed merely for the purpose of providing a dependable source of supply should another emergency arise. With that in view, the probabilities

for commercial success seem encouraging. The very latest evidence of faith in American potash is shown in the recent undertaking of a new potash group, known as "Potash of America", a hundred per cent American enterprise, financed and owned by Denver and Chicago capitalists. Mining operations by this company will begin as soon as a mine shaft near Carlsbad, New Mexico, is completed. Adjacent to the property of "Potash of America" are the shafts of the United States Potash Company, owned partly by south-western oil magnates and partly by British borax interests. If estimates are to be relied upon, the combined production of these companies turn the key to the American problem for as the following report states:[1]

"The potash (K_2O) production capacity of these two mines combined with the recovery capacity of British-owned American Potash and Chemical Company, Searles Lake, California, are more than 250 million tons per year, substantially more than current domestic needs for both fertilizers and chemicals."

On the strength of past developments it seems more conservative to state that the American industry will have to undergo a gradual evolution rather than become an over-night reality. Those who enter the industry now and in the near future are still pioneers,

1. Business Week, February, 1933.

whose success or failure lies within the realm of chance.

Germany has not yet released its hold on the American market, nor is there any indication that it will, until more conclusive proof of success will be offered to inspire the American industry.

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